DESCRIPTION

OXYGEN CONCENTRATING APPARATUS

Technical Field

The present invention relates to an oxygen concentrating apparatus used for medical treatment in which oxygen is concentrated from air by using adsorbent for selectively adsorbing nitrogen gas.

Background Art

As one of the effective medical treatment methods to treat a patient for a disease of the respiratory such as pulmonary emphysema or chronic bronchitis, the medical treatment of oxygen inhalation is employed. In the medical treatment of oxygen inhalation, oxygen enriched gas, which is generated by separating nitrogen gas from air, is supplied to a patient. In order to accomplish this object, they have developed oxygen concentrators for generating oxygen enriched gas from air.

As an example of the oxygen concentrators described above, the United States Patent No. 6,311,719 B1 describes a pressure swing adsorption (PSA) system provided with a plurality of nitrogen adsorption cylinders. For the medical treatment of oxygen inhalation conducted on a patient at home, a small oxygen concentrating apparatus, in which an oxygen concentrator and a compressor for supplying compressed air to the oxygen concentrator are combined with each other, has already been offered. Since this type oxygen concentrating apparatus is used at home, it is necessary to reduce the noise generated by the compressor and cooling fan.

In order to reduce the noise generated by each component of the oxygen concentrating apparatus, for example, the official gazettes of Japanese Unexamined Patent Publication Nos. 61-155204, 60-200804 and 2-211175

disclose an oxygen concentrating apparatus including: a sound insulation box made of metal surrounding a compressor and cooling fan; and an exhaust duct for guiding exhaust, which is sent from the cooling fan, to the outside, wherein the exhaust duct is formed into a bent passage having a plurality of bend sections.

However, the prior art described above has the following problems.

In the case where the sound insulation box made of metal surrounding the compressor and cooling fan is provided, when air is supplied from the compressor to the oxygen concentrator, pressure fluctuation is caused in the sound insulation box made of metal by the action of noise. Due to this pressure fluctuation, a side wall of the sound insulation box is vibrated especially in the low frequency region of 100 to 400 Hz. Therefore, the sound insulation box could become a new noise source.

When the plurality of bend sections are formed in the duct through which exhaust sent from the cooling fan is discharged, the exhaust noise generated from the cooling fan can be reduced, however, the entire size of the oxygen concentrating apparatus is extended, and the pressure loss of the duct is increased.

Disclosure of the Invention

It is a technical task of the present invention to solve the above problems of the prior art. An object of the present invention is to provide an oxygen concentrating apparatus, the noise level of which is reduced while the oxygen concentrating apparatus is being downsized.

According to the present invention, there is provided an oxygen concentrating apparatus for generating oxygen enriched gas by adsorbing and separating nitrogen gas from air, comprising: an oxygen concentrator having an adsorption cylinder filled with adsorbent for adsorbing nitrogen gas, also having an air inlet port, an

oxygen outlet port and a nitrogen gas outlet port; a compressor for supplying compressed air from the air inlet port; a sound insulation box, which surrounds the compressor, for reducing noise generated from the compressor, ribs being formed on a side wall of the sound insulation box; a cooling fan for introducing air into the sound insulation box so as to cool the compressor by the introduced air; a housing surrounding the oxygen concentrator and the sound insulation box; and an exhaust duct arranged in the housing, for guiding the exhaust discharged from the cooling fan to the outside of the housing.

According to another characteristic of the present invention, there is provided an oxygen concentrating apparatus for generating oxygen enriched gas by adsorbing and separating nitrogen gas from air, comprising: an oxygen concentrator having an adsorption cylinder filled with adsorbent for adsorbing nitrogen gas, also having an air inlet port, an oxygen outlet port and a nitrogen gas outlet port; a compressor for supplying compressed air from the air inlet port; a sound insulation box, which surrounds the compressor, for reducing noise generated from the compressor, ribs being formed on a side wall of the sound insulation box; a cooling fan for introducing air into the sound insulation box so as to cool the compressor by the introduced air; a housing surrounding the oxygen concentrator and the sound insulation box; and an exhaust duct arranged in the housing, for guiding the exhaust discharged from the cooling fan to the outside of the housing, wherein

the exhaust duct includes a hollow outer shell having a horizontal portion and a perpendicular portion, which is connected to one end portion of the horizontal portion via one bend section so that the hollow outer shell can be extended into a substantial L-shape, and also includes a sound absorbing member of 2 to 20 mm thickness which is stuck onto an inner face of the hollow

outer shell, the other end portion of the horizontal portion of the hollow outer shell is communicated with an outlet of air of the cooling fan, a lower end portion of the perpendicular portion is arranged in the housing so that it can be communicated with the exhaust port, and a cross sectional area of the exhaust duct is 12 to 20 cm^2 and the length of the exhaust duct is 350 to 450 mm.

Brief Description of the Drawings

Fig. 1 is a view showing an outline of an oxygen concentrating apparatus of the present invention.

Fig. 2 is a sectional view showing a rib formed on a side wall of a sound insulation box.

Fig. 3 is a graph in which a comparison is made between the noise level of the oxygen concentrating apparatus of the present invention and the noise level of the oxygen concentrating apparatus of the prior art, wherein the comparison is made in each frequency region.

Fig. 4 is a sectional view of an exhaust duct.

Most Preferred Embodiment of the Present Invention

Referring to Fig. 1, the oxygen concentrating apparatus 10 of the most preferred embodiment of the present invention includes: a housing 12; an oxygen concentrator 40 arranged in the housing 12; a compressor 30 for supplying compressed air to the oxygen concentrator 40; a cooling fan 36 for circulating air in the housing 12 so as to cool the housing 12; an exhaust duct 60 for guiding exhaust sent from the cooling fan to the outside of the housing 12; and an electric control unit 15 for controlling the oxygen concentrator 40, the compressor 30 and the cooling fan 36.

The housing 12 includes: an air inlet 12a composed of a plurality of small halls formed on the side wall; and an exhaust port 12b composed of a plurality of small halls formed on the bottom wall. Onto the top wall of the housing 12, an ON-OFF switch for starting and

stopping the oxygen concentrating apparatus 10 and one or a plurality of switches 16, which include the adjusting knob for setting a flow rate of condensed oxygen, are attached. Further, the display unit 18 is attached onto the top wall of the housing 12. The adjusting knob 16 and the display unit 18 are connected to the electric control unit 15. Further, a plurality of wheels 14 capable of freely moving the housing 12 are attached to the bottom wall of the housing 12.

It is possible to use various types of oxygen concentrators 40, however, it is preferable to use an oxygen concentrator having one or a plurality of adsorption cylinders filled with zeolite. In this connection, only one adsorption cylinder is shown in Fig. 1. For example, it is possible to use an oxygen concentrator, the brand name of which is AFT Module, which is available in the market from SeQual Technologies Inc., located in San Diego, California, wherein PSA system disclosed in United States Patent No. 6,311, 719 B1 is applied to this oxygen concentrator so that nitrogen gas can be separated from air. In this specification, the content of United States Patent No. 6,311, 719 B1 is incorporated by reference. Although the detail are not shown in Fig. 1, the oxygen concentrator 40 includes: one or a plurality of adsorption cylinders filled with adsorbent for selectively adsorbing nitrogen gas, for example, one or a plurality of adsorption cylinders filled with zeolite; an air inlet port 44; an oxygen outlet port 50; and a nitrogen gas outlet port 46. The oxygen outlet port 50 is fluidly communicated with an outlet port 54 of the oxygen concentrating apparatus 10 via an oxygen pipe 52.

The compressor 30 and the cooling fan 36 are surrounded by the sound insulation box 20 in the housing 12. The sound insulation box 20 can be made of plastics or metallic material. The sound insulation box 20 includes: an air inlet opening 24 formed in a lower

portion of one side wall; and an opening (not shown) forming an air outlet of the cooling fan 36 described later. At a position higher than the air inlet opening 24 in the sound insulation box 20, the partition wall 22 is horizontally arranged which partitions the inside of the sound insulation box 20 into an upper space and a lower space. In the partition wall 22, the cooling air passage 22a for fluidly communicating the upper space with the inner space is formed. As shown in Figs. 1 and 2, on at least one side wall of the sound insulation box 20, ribs 20a are diagonally provided. Further, in the sound insulation box 20, the upper space on the upper side of the partition wall 22 is communicated with the nitrogen gas outlet port 46 of the oxygen concentrator 40 via the nitrogen gas pipe 48.

The compressor 30 is arranged on an upper face of the partition wall 22. The compressor 30 may be one of the reciprocating piston compressor, the rotary compressor, the scroll compressor, the screw compressor and the oscillating compressor. The compressor 30 includes: a suction pipe 32 penetrating the partition wall 22; and a discharge port (not shown) for discharging the compressed air, so that the upper space of the sound insulation box 20 can be communicated with the lower space which is lower than the partition wall 22 of the sound insulation box 20. The discharge port is connected to the air inlet port 44 of the oxygen concentrator 40 via the air supply pipe 34. It is preferable that the vibration proofing members 26 made of rubber or plastics are arranged between the compressor 30 and the upper face of the partition wall 22.

In the sound insulation box 20, the cooling fan 36 is arranged in an upper portion of the compressor 30. This cooling fan 36 can be an axial fan, a sirocco fan and so forth. The cooling fan 36 includes: an air inlet (not shown) arranged so that air can be sucked from the neighborhood of the compressor 30 in the upper space in

the housing 12; and an air outlet (not shown) arranged so that the sucked air can be discharged to the outside of the sound insulation box 20. The air outlet is communicated with the exhaust duct 60 via a connecting pipe 28 made of rubber.

The exhaust duct 60 is provided with an outer shell 62 (shown in Fig. 4) composed of a substantially L-shaped hollow member including a horizontal portion and a perpendicular portion which is connected to one end portion of the horizontal portion via one bend section. The connecting pipe is connected to an upper inlet of the hollow member. A lower exit of the hollow member is communicated with the exhaust port 12b. Referring to Fig. 4, the exhaust duct 60 includes: an outer shell 62, the cross section of which is a rectangle having side walls 1 to 4; and a sound absorbing member stuck onto the inner face of the outer shell 62. The outer shell 62 can be made of plastic materials such as acrylic nitrile butadiene styrene (ABS), polypropylene (PP), polyethylene (PE), polystyrene (PS), polybutylene terephthalate (PBT), and polyethylene terephthalate (PET). The outer shell 62 can be also made of metallic materials such as a plated steel sheet and an aluminum sheet. Alternatively, the outer shell 62 can be also made of wood. Alternatively, the outer shell 62 may be made of a compound material in which the above plastic materials and reinforced fiber such as glass fiber or carbon fiber are compounded with each other. Concerning the sound absorbing material, it is preferable to use porous plastic material. Especially, it is preferable to use soft urethane foam. In this connection, the exhaust duct illustrated in Fig. 4 has a rectangular cross section, however, the exhaust duct may have a circular cross section.

Operation of the present embodiment will be explained as follows.

When a user turns on ON-OFF switch of the oxygen concentrating apparatus 10, the compressor 30 and the

cooling fan 36 are set in motion. Due to the start of the compressor 30 and the cooling fan 36, air in the periphery of the oxygen concentrating apparatus 10 is sucked from the air inlet 12a into the housing 12. It is preferable that the deflecting plate 56 is arranged in the housing 12 as shown in Fig. 1 and the air, which has flowed from the air inlet 12a into the housing 12, is moved upward toward the electric control unit 15 inside the housing 12 as shown by arrow A so that the electric control unit 15 can be cooled by the air.

Air that has flowed into the housing 12 is sucked from the air inlet opening 24, which is formed in a lower portion of the side wall of the sound insulation box 20, into the lower space in the sound insulation box 20. A portion of the air in the lower space on the lower side of the partition wall 22 in the housing 12 is sucked into the compressor 30 via the suction pipe 32 and compressed by the compressor 30. The air compressed by the compressor 30 is supplied to the oxygen condensation device 40 via the air supply pipe 34 and the air inlet port 44.

In the oxygen condensation apparatus 40, nitrogen gas is adsorbed and separated from air by the adsorbent, and oxygen enriched gas, the oxygen concentration of which is at least 90% (volume), is generated. This oxygen enriched gas is supplied to the output port 54 of the oxygen concentrating apparatus 10 via the oxygen outlet port 50 and the oxygen pipe 52. A user connects one end of a conduit tube (not shown) to the output port 54 and receives the oxygen condensation gas via a nasal mask (not shown) or nasal prong (not shown) connected to the other end of the conduit tube. The nitrogen gas adsorbed by the adsorbent is released from the adsorbent when the adsorbing cylinder is depressurized in the process of regenerating the adsorbent, and discharged into the upper space on the upper side of the partition wall 22 via the nitrogen gas outlet port 46 and the

nitrogen gas pipe 48 in the sound insulation box 20.

A portion of the remaining air in the lower space in the housing 12 is sucked by the cooling fan 36 and flows into the upper space via the cooling air passage 22a of the partition wall 22. When this air passes in the neighborhood of the compressor 30, the compressor 30 is cooled by the air. After the air has cooled the compressor 30, it passes through the cooling fan 36. Then, the air is discharged from the exhaust port 12b to the outside via the connecting pipe 28 and the exhaust duct 60.

As described before, according to the prior art in which the rib 20a is not formed on the sound insulation box 20, the side wall of the sound insulation box is vibrated in the low frequency region of 100 to 400 Hz by the pressure fluctuation caused in the sound insulation box by the noise which is generated when the compressor 30 is started and the air is supplied to the oxygen concentrator 40. On the other hand, according to the present invention, since the rib 20a is formed on the side wall of the sound insulation box 20, the rigidity of the side wall is enhanced. Therefore, it becomes possible to reduce the vibration of the side wall of the sound insulation box 20. Fig. 3 is a graph in which a comparison is made between the noise level of the oxygen concentrating apparatus 40 of the present invention and the noise level of the oxygen concentrating apparatus of the prior art, wherein the comparison is made in each frequency region. Referring to Fig. 3, it can be understood that the sound pressure level is decreased in the low frequency region of 100 to 400 Hz according to the present invention.

On Table 1 shown below, a comparison is made between the present invention and Comparative Examples 1 to 3 with respect to the effect of reducing the noise in the exhaust duct and the pressure loss. In the experiment, an oxygen concentrator was used in which PSA system

having 12 adsorbing cylinders filled with zeolite was provided. This oxygen concentrator was capable of generating oxygen enriched gas, the concentration of which was not less than 90%, by the volume of 3×10^{-3} m^3/min at the maximum. The exhaust duct 60 of the present invention used for the experiment included: a rectangular cross section; one bend section; a cross section of 18 cm^3; an outer shell 62 made of ABS, the total length of which was 400 mm; and a sound absorbing member 64 made of soft urethane foam which was stuck on the inner face of the outer shell 62. Concerning the thickness t of the sound absorbing member 64, the thickness t was 15 mm on the side wall 1, the thickness t was 10 mm on the side wall 2, the thickness t was 5 mm on the side wall 3, and the thickness t was 10 mm on the side wall 4.

TABLE 1

	Present Invention	Comparativo Example 1	Comparative Example 2	Comparative Example 3
Flow Rate of Oxygen Enriched Gas ($\times 10^{-3} m^3$/min)	3	3	3	3
Oxygen Concentration (%)	93	93	93	93
Number of Bend Section of Exhaust Duct	1	3	1	1
Cross Sectional Area of Exhaust Duct (cm^2)	18	25	9	18
Length of Exhaust Duct (mm)	400	700	400	600
Thickness of Sound Absorbing Material (mm)	side wall 1:10 side wall 2:15 side wall 3:5 side wall 4:10	side wall 1:10 side wall 2:10 side wall 3:10 side wall 4:10	side wall 1:10 side wall 2:15 side wall 3:5 side wall 4:10	side wall 1:10 side wall 2:15 side wall 3:5 side wall 4:10
Noise Level (dB (A))	30.5	29.0	31.0	31.0
Pressure Loss (Pa)	45.1	98.1	78.5	68.6
Volume of Housing ($\times 10^{-3} m^3$)	53	65	58	58

As can be understood from Table 1, in the case of Comparative Example 1 having three bent portions, the noise level is 29.0 dB(A). Therefore, it is possible to reduce the noise level as compared with the present invention. However, since the number of the bent portions is increased, the total length of the duct is extended. Accordingly, it is necessary to extend the inner volume of the housing. In the case of Comparative Example 2 in which the cross sectional area of the duct is reduced, since the pressure loss of the exhaust duct is increased, it is necessary to extend a capacity of the cooling fan. Accordingly, the inner volume of the housing must be increased. Further, when the length of the duct is increased like the case of Comparative Example 3, the inner volume of the housing must be increased, and it becomes difficult to reduce the noise level.